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Evaluation of neem as a bird repellent chemical

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Abstract. Neem extract (*Azadirachta indica*) is effective as an insect antifeedant, and limited evidence suggests that it may be useful as a repellent for birds. The present experiments were designed to test this proposition. In Experiment 1, European Starlings (*Sturnus vulgaris*) were presented with feed adulterated with a commercially available neem preparation (Nimin®). The results showed that the highest test concentration (1·5% m/m) was avoided. In Experiment 2, starlings were presented with an aqueous extract of neem leaves and serial dilutions of that extract. All extract concentrations were avoided relative to untreated water. We conclude that neem is an economical and biologically safe bird repellent and that it may be useful in developing nations where neem is indigenous or introduced, and when synthetic pesticides are difficult to obtain or expensive.

1. Introduction

Natural products and their analogues from higher plants are an important source of new agricultural chemicals (Cardellina, 1988; Cutler, 1988). At least some of these natural chemicals pose little environmental risk because they do not bioaccumulate and because they show specific biological activity (Cardellina, 1988). An additional benefit is that natural product pesticides are sometimes available and cost effective in countries where synthetic pesticides are expensive and difficult to obtain (Shivanarayan and Rao, 1988).

Triterpenoid substances may represent especially promising sources of new natural pesticides. For example, cucurbitacins are triterpenoid glycosides that occur chiefly in plants belonging to the Cucurbitacae and Cruciferae families (Guha and Sen, 1975; Robinson, 1983). These materials are effective insect antifeedants (Neilson *et al.*, 1977; Metcalf *et al.*, 1980), and extremely bitter to humans (David and Vallance, 1955; Metcalf *et al.*, 1981). This bitterness undoubtedly reduces the risk of accidental ingestion, although poisoning incidents occasionally occur (Watt and Breyer-Brandwijk, 1962; Ferguson *et al.*, 1983). In laboratory tests, cucurbitacins are not repellent to birds (Mason and Turpin, 1990).

Recently, triterpenes extracted from the Indian neem tree (*Azadirachta indica*) have become available in western countries as botanical insecticides for ornamentals, trees, and shrubs (Bioneem®, Ringer Corp., Eden Prarie, Minn., USA; EPA Reg. No. 11888-5-42697). There is limited evidence that neem also may be repellent to some species of mammals (Gope *et al.*, 1988) and birds (M. L. Avery, unpubl. data; Shivanarayan and Rao, 1988; Rao *et al.*, 1990), although repellency may be context specific (e.g. Sengupta 1981 reports that House Sparrows (*Passer domesticus*) line their nests with neem leaves). The possibility of repellency in feeding situations is important because neem is available to farmers in India that do not have ready access to other bird repellent chemicals.

The present experiments were designed to assess whether a commercial neem concentrate (Nimin®, Godrej Agrovet Ltd. Bombay, India) or an aqueous extract of dried neem leaves would repel European Starlings in laboratory feeding tests.

2. Materials and methods

2.1. Subjects

Forty European Starlings were decoy-trapped and transported to the laboratory. This species was chosen because of the global distribution of the genus *Sturnus* (Feare, 1984), and because European Starlings have well-developed chemosensory abilities (Clark and Mason, 1987). Upon arrival, each bird was weighed, and individually caged ($61 \times 36 \times 41\,cm^3$) under a 12:12 light:dark cycle. All birds were given free access to Purina Flight Bird Conditioner (feed; Purina Mills, St Louis, Mo.), and water. After 2 weeks adaptation to laboratory conditions, 20 birds were selected randomly for use in Experiment 1. The remaining birds served as subjects in Experiment 2.

2.2. Stimuli

Neem concentrate (Nimin®), was obtained from Godrej Agrovet Ltd (Bombay 400-079, India) and stored at room temperature (20 C). For use, this stimulus was dissolved in ethyl ether and then thoroughly mixed with feed (Jakubas *et al.*, 1992). Prepared feed samples were placed under a fume hood for 24 h to evaporate the ether. The second stimulus was an aqueous neem extract prepared by immersing 100 g of dried leaves in a litre of tapwater for 24 h, and then filtering the liquid to remove particulate matter. The liquid was refrigerated (8·5 C) prior to use.

2.3. Procedure

2.3.1. *Experiment 1.* During a 5-day pretreatment period, each bird was presented with a cup containing 20 g of feed at 0800 h (= 'dawn'). After 2 h, the food cups were removed from

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the cages and the amount of feed remaining in each was weighed. During the remainder of each light period, the birds were given free access to feed and tapwater. Feed was removed from the cages overnight so that animals were moderately food-deprived.

At the end of the pretreatment period, birds were assigned to four groups ($n = 5$/group), counterbalanced on the basis of mean consumption. During the 4-day treatment period that followed, each group was presented with a different order of feed samples containing 0·0%, 0·5%, 1·0%, or 1·5% Nimin^{R} in 2-h one-cup tests. As in pretreatment, testing occurred between 0800 and 1000 h, and plain feed and water were freely available between 1000 and 1800 h. Birds were food-deprived overnight.

2.3.2. *Experiment 2.* The remaining 20 experimentally naive starlings were given calibrated drinking tubes containing 20 ml of tapwater at 0800 h on each of five pretreatment days. At 1400 h the amount of fluid remaining in the tube was measured, and then all birds were given free access to tapwater and feed until lights out (1800 h). Birds were food- and water-deprived overnight.

At the end of the pretreatment period, the birds were assigned to four groups ($n = 5$/group), counterbalanced on the basis of consumption. During the 4-day treatment period that followed, each group was presented with a different order of the aqueous extract of dried neem leaves and three serial dilutions of that extract. As in pretreatment, testing occurred between 0800 and 1000 h, plain feed and water were freely available between 1000 and 1800 h, and birds were food-and water-deprived overnight.

2.4. Analysis

Feed consumption in Experiment 1 was evaluated in a single factor (concentration, four levels) repeated measures analysis of variance. Likewise, fluid consumption in Experiment 2 was evaluated in a single factor (concentration, five levels) repeated measures analysis of variance. Pretreatment drinking was included as a level of the factor. Tukey's *post-hoc* tests (Winer, 1962) were used to isolate significant differences among means ($P < 0·05$).

3. Results

3.1. Experiment 1

There were significant differences among concentrations ($F = 17·7$; 3,48 df; $P < 0·00001$). *Post-hoc* evaluation of this effect showed only that consumption of feed adulterated with the highest neem concentration was less than consumption of plain feed (Figure 1). Otherwise, there were no significant differences.

3.2. Experiment 2

There were significant differences among concentrations ($F = 13·56$; 4,76 df; $P < 0·00001$). *Post-hoc* tests showed that all neem concentrations reduced drinking relative to pretreatment consumption (Figure 2). In addition, the unadulterated

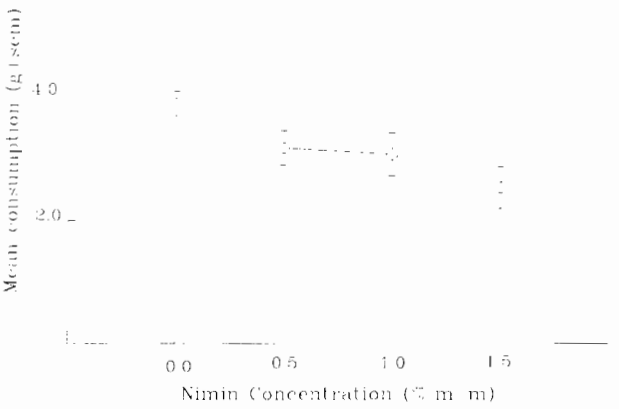

Figure 1. Mean consumption of feed adulterated with Nimin^{R} by European Starlings. Capped vertical bars represent standard errors of the means.

extract produced significantly greater reductions in drinking than any of the serial dilutions.

4. Discussion and management implications

The present results suggest that an aqueous extract of neem leaves and, to a lesser extent, a commercially available neem product, may serve as feeding and drinking repellents to European Starlings. These results are consistent with and extend previous findings. In previous work (Gope *et al.*, 1988; Shivanarayan and Rao, 1988; Rao *et al.*, 1990), neem cake prepared from crushed whole plants appeared to show some repellency to several avian species, including Parrots (*Psittacula krameri*), House Sparrows (*Passer domesticus*) and Weaver Birds (*Ploceus phillippinus*, *Lonchura* sp.). While these materials appeared to have some effectiveness, the present results suggest that a simple water extract of neem leaves might be more effective.

This result is intriguing, because azadirachtin, the tetranortriterpenoid in neem that acts as an insect feeding deterrent is not especially water soluble (Budavari *et al.*, 1989). Also, while azadirachtin appears at higher concentrations in neem seeds than in neem leaves, the seeds are palatable to chickens (*Gallus domesticus*; Salawn *et al.*, 1994), and eaten

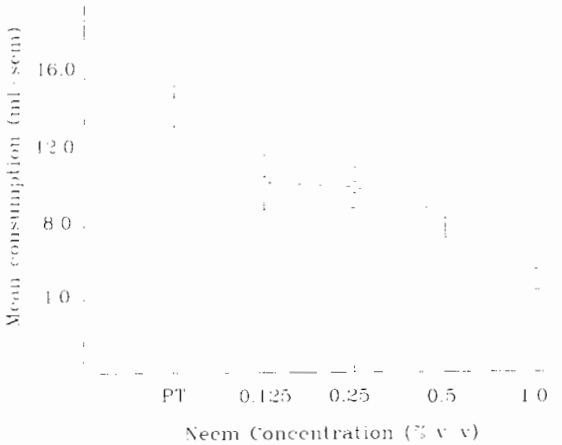

Figure 2. Mean consumption of an aqueous extract of neem leaves, and three serial dilutions of this extract. Consumption of 0·0% (volume/volume) extract is mean drinking during the pretreatment period. Capped vertical bars represent standard errors of the means.

by wild birds, including Ring-necked Parakeets (*Psittacula krameri*; Forshaw, 1989), and Brahminy Mynas (*Sturnus pagodarum*, Patel *et al.*, 1992). This suggests the absence of repellent chemicals. Perhaps, factors other than (or in addition to) azadirachtin may be mediating the bird repellent properties of the neem plant. One means to test this possibility would be to prepare a methanol extract of neem leaves and then compare the repellency of this extract with that of a water extract. The methanol extract would contain all or most of the azadirachtin in the leaves. Regardless, the present results support the view that neem is a promising bird repellent that is economical for use in India and other areas where the neem tree is indigenous and synthetic pesticides are expensive and relatively difficult to obtain.

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References

BUDAVARI, S., O'NEIL, M. J., SMITH, A. and HECKELMAN, P. E., 1989. *The Merck Index* (Rahway, NJ: Merck and Co.), p. 142.

CARDELLINA, J. H., 1988. Natural products in the search for new agrochemicals. In H. G. Cutler (ed) *Biologically Active Natural Products: Potential Use in Agriculture* (Washington: American Chemical Society), pp. 305–311.

CLARK, L. and MASON, J. R., 1987. Olfactory discrimination of plant volatiles by the European starling. *Animal Behavior*, **35**, 227–235.

CUTLER, H. G., 1988. Natural products and their potential in agriculture: a personal overview. In H. G. Cutler (ed) *Biologically Active Natural Products: Potential Use in Agriculture* (Washington: American Chemical Society), pp. 1–22.

DAVID, A. and VALLANCE, D. K., 1995. Bitter principles of cucurbitaceae. *Journal of Pharmacy and Pharmacology*, **7**, 295–296.

FEARE, C. J., 1984. *The Starling* (Oxford: Oxford University Press), 315 pp.

FERGUSON, J. E., FISCHER, D. C. and METCALF, R. L., 1983. A report of cucurbitacin poisoning in humans. *Cucurbit Genetics*, **6**, 73–74.

FORSHAW, J. M., 1989. *Parrots of the World* (London: Blanford Press), 672 pp.

GOPE, B., MUKHERJEE, S. and DAS, S. C., 1988. Neem oil cake as goat repellent. *Two and A Bud*, **35**, 48–49.

GUHA, J. and SEN, S. P., 1975. The cucurbitacins: a review. *Plant Biochemistry*, **2**, 12–28.

JAKUBAS, W. J., SHAH, P. S., MASON, J. R. and NORMAN, D. M., 1992. Avian repellency of coniferyl and cinnamyl derivatives. *Ecological Applications*, **2**, 147–156.

MASON, J. R. and TURPIN, T., 1990. Cucurbitacin-adulterated diet is avoided by captive European starlings. *Journal of Wildlife Management*, **54**, 672–676.

METCALF, R. L., METCALF, R. A. and RHODES, A. M., 1980. Cucurbitacins as kairomones for diabroticite beetles. *Proceedings of the National Academy of Sciences, USA*, **77**, 3769–3772.

METCALF, R. L., METCALF., E. R. and MITCHELL, W. C., 1981. Molecular parameters and olfaction in the oriental fruitfly *Dacus dorsalis*. *Proceedings of the National Academy of Sciences, USA*, **78**, 4007–4010.

NEILSON, J. K., LARSEN, L. M. and SORENSON, H. J., 1977. Cucurbitacins E and I in *Iberis amara*, feeding inhibitors for *Phyllotreta nemorum*. *Phytochemistry*, **16**, 1519–1522.

PATEL, J. R., YADAV, D. N., MATTHEW, K. L. and PARASHARYA, B. M., 1992. The food of nestling Brahminy myna *Sturnus pagodarum* (Gemlin). *Pavo*, **30**, 109–117.

RAO, M. A., VARDHANI, B. P. and RAO, P. S., 1990. Effect of botanical pesticides as repellent on bird predators. *Proceedings of the Symposium on Botanical Pesticides in Integrated Pest Management*, **1**, 473–477.

ROBINSON, T. V., 1983. *The Organic Constituents of Higher Plants* (North Amherst, Massachusetts: Cordus Press), 353 pp.

SALAWN, M. B., ADEDEJI, S. K. and HASSAN, W. H., 1994. Performance of broilers and rabbits given diets containing full-fat neem (*Azadirachta Indica*) seed meal. *Animal Production*, **58**, 285–289.

SENGUPTA, S., 1981. Adaptive significance of the use of margosa leaves in nests of the house sparrow *Passer domesticus*. *Emu*, **81**, 114–115.

SHIVANARAYAN, N. and RAO, M. A., 1988. Efficacy of neem cake as bird pest repellent on maize. *Pavo*, **26**, 49–52.

WATT, J. M. and BREYER-BRANDWIJK, M. G., 1962. *The Medicinal and Poisonous Plants of Southern and Eastern Africa* (Edinburgh: E. S. Livingston), 1457 pp.

WINER, C. J., 1962. *Statistical Principles in Experimental Design* (New York: McGraw-Hill Book Company), p. 198.